EP-1212

Empirical estimation of beam-on time for prostate cancer patients treated on Tomotherapy

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Purpose/Objective: This study proposed a method to estimate the beam-on time for prostate cancer patients treated on Tomotherapy when FW (field width), PF (pitch factor), modulation factor (MF) and treatment length (TL) were given.
Materials and Methods: The study was divided into two parts: building and verifying the model. To build a model, 160 treatment plans were created for 10 patients. The plans differed in combination of FW, PF and MF. For all plans a graph of beam-on time as a function of TL was created and a linear trend function was fitted. Equation for each trend line was determined and used in a correlation model. Finally, 40 plans verified the treatment time computation model - the real execution time was compared with our estimation and irradiation time calculated based on the equation provided by the manufacturer.
Results: A linear trend function was drawn and the Pearson correlation coefficient r were calculated for each of the 8 trend lines corresponding to the adequate treatment plan. An equation to correct the model was determined to estimate more accurately the beam-on time for different MFs. Correlation was found to be high since for all plans r was higher than 0.98. The data showed that the estimation suggested by the manufacturer tended to underestimate the beam-on time on average by 52sec. However, differences of up to 154sec were observed. Whereas, the estimation based on the correlation model overestimated the treatment time on average by 14sec. In Figure 1B, an advantage of the correlation model might be observed, since the most frequent beam-on time differences were below 10% and the data were distributed almost symmetrically (skewness=- 0.08) which might suggest a good assessment of our model.

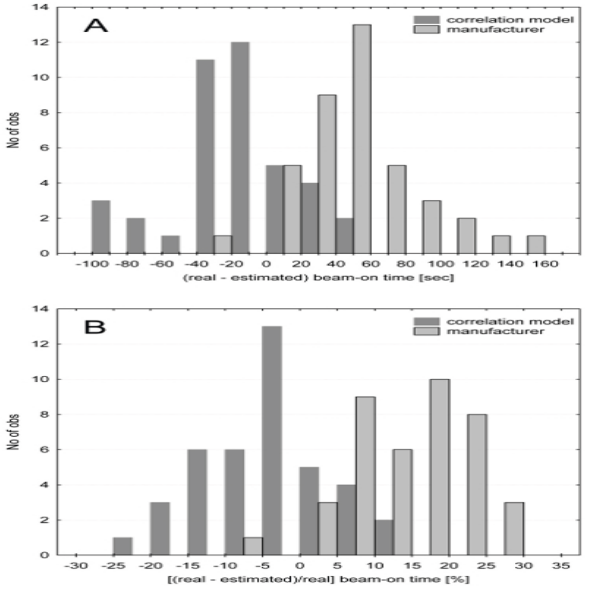

Figure 1. Histogram of differences between real (from HT system) and estimated (from correlation model or manufacturer equation) beam-on time in seconds (A) and percentage (B).

Conclusions: Our study showed that the model can well predict the treatment time for a given TL, MF, FW and it can be used in clinical practice.

EP-1213

Commissioning and developing the use of 6MV flattening filter free

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Purpose/Objective: To discuss key points identified during the commissioning of 6MV flattening filter free (FFF) and to identify treatment sites routinely treated using RapidArc© (Varian Medical Systems, Palo Alto) that could benefit from 6MVFFF.

Materials and Methods: 6MVFFF was calibrated on the TrueBeam® linear accelerator (Varian Medical systems, Palo Alto) following the UK photon code of practice and the recommendations of Xiong et al (2008). Beam data was collected and the beam model configured in the Varian Eclipse TPS. The beam model was compared to measured data. Equipment routinely used for quality assurance, including the seven29 array (PTW, Freiburg), was tested in the high dose rate 6MVFFF beam. To identify sites which may benefit from FFF a number of prostate and multi dose level head and neck patients were replanned using RapidArc© with 6MVFFF and 6MV flattened beams. All plans were optimised to produce clinically acceptable plans based on departmental protocols. For each plan the conformity index and homogeneity index were calculated and site specific organ doses were compared.
Results: The 6MVFFF beam has been successfully calibrated with a correction of -0.5% being applied to k_Q. The seven29 array with Octavius phantom can accurately measure dose at a dose rate of 1400MU/min provided the measurement interval is adjusted to 200ms, but the QA BeamChecker™ Plus (Standard Imaging, United States) saturates at dose rates of 1400MU/min. However it is capable of accurately measuring at 1200MU/min.
For standard prostate RapidArc treatments table one demonstrates there is no clinical benefit in using 6MVFFF over 6MV. All organs were within the departmental tolerances with no individual organ benefitting significantly from the FFF beam. For head and neck patients it seems there may be a benefit in using 6MVFFF. For organs further away from the PTV it is easier to meet the dose constraints and maximum doses in these organs are lower. This is due to the natural shape of the beam. For organs close to the PTV it is often possible to reduce the maximum dose as well.

	Average conformity index PTV1	Standard deviation	Average conformity index PTV2	Standard deviation	Average homogeneity index PTV1	Standard deviation	Average homogeneity index PTV2	Standard deviation
6MV	1.06	0.004	1.14	0.05	1.06	0.004	1.06	0.0003
6MVFFF	1.10	0.07	1.13	0.04	1.06	0.002	1.06	0.0003

Table 1: Comparison of conformity index and homogeneity index for prostate treatments planned with 6MV flattened and FFF beams

Conclusions: Further guidance on the calibration of these beams and possibly the development of a calibration procedure in FFF beams is necessary. Existing equipment can be successfully used in these high dose rate beams although it is sometimes necessary to limit the dose rate.
Initial data suggests that FFF beams won't benefit standard prostate treatments, but may help reduce the maximum dose to critical organs in head and neck treatments.

EP-1214

Implementation of an advanced treatment planning algorithm in the treatment of lung cancer

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Purpose/Objective: Modern TPSs are coming with advanced dose calculation algorithms such as superposition. However, when using superposition algorithms it is more difficult to achieve ICRU 50 recommendations (i.e. a minimum of 95% of the prescribed dose to the PTV) than with the old pencil beam convolution based algorithms due to the more accurate representation of the dose in heterogeneous media. The aim of this study was to determine the differences of dose calculations in lungs between two algorithms, and compare the calculations to measured doses.
Materials and Methods: Semi-anthropomorphic phantom CIRS Thorax 002 LFC was CT scanned and transferred to TPS. The phantom is elliptical in shape and represents an average human torso in proportion, density and two-dimensional structure. Plans were calculated according to IAEA TECDOC 1583 for verification of TPS, and measurements with ion chamber were conducted afterwards. Also, comparison of dose calculations for different clinical lung treatment plans were carried out for further 10 patients. Patient plans were calculated by both algorithms, but irradiated according to the results of the superposition algorithm. Also, old patient plans, clinically calculated and irradiated according to pencil beam calculations, were re-calculated by superposition, and differences evaluated.
Results: The systematic dose overestimation by up to 15 % for the pencil beam convolution algorithm was recorded for all measurement points located inside the lung equivalent material. The range of

deviations was related to the beam energy, i.e. larger deviations were observed for the higher beam energy. The overall treatment time calculated with superposition was 5-7 % longer in comparison to the calculation of convolution, and the coverage of PTV, in terms of 95% isodose, was better (up to 18%). Hot spots were lower for superposition plans for both low and high energies.
Conclusions: Convolution algorithms are not adequate for dose calculations in the presence of and inside low density inhomogeneities, while the superposition algorithm showed better agreement for all cases.Convolution algorithm overestimates the delivered dose, which leads to the underdosage of the target volume in reality. This applies both to lower energy and even more to higher energy beams. Differences between doses calculated with superposition and convolution algorithms are primarily due to changes in electron transport in the lungs, which is not adequately taken into account by convolution algorithm. Following these findings, and recommendations from the literature all lung patients is planned with superposition algorithm.
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EP-1215
The effect of photon energy on the intensity-modulated radiation therapy (IMRT) plans for prostate cancer
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Purpose/Objective: To evaluate the effect of 6, 15 MV and mixed energy (6&15MV) on intensity-modulated radiation therapy (IMRT) plans for prostate cancer using the equivalent uniform dose (EUD) and normal tissue complication probability (NTCP).
Materials and Methods: In this study, immobilization and CT simulation were performed for 15 prostate cancer patients, as is routine for prostate cancer patients receiving IMRT in our department. The treatment position is supine with kneefix. Using the simulator lasers, patients were aligned and marked to define the coordinate system to be used for treatment planning. The patients were scanned in treatment position on Siemens Emotion Duo using 5-mm slice thickness. The data transferred to the treatment planning system. The determination of the 15 prostate cancer patient's target volume and critical tissues are initially done by using CT images obtained in our clinic. After definition of the critical organs which are rectum, bladder and femoral heads, three different IMRT plans were done for each of 15 patients using 6 MV, 15 MV and mixed 6 and 15 MV energies using similar dose constraints and 8-fields setting. Gantry angles of 225º,260º, 295º, 330º, 65º, 100ºand 135º are used in our clinic for IMRT plans for prostate cancer. For the plan of mixed-energy, 15 MV photon beams at the gantry angles of 100ºand 260º were used while 6 MV were used for the rest of the gantry angles.The dose distributions were similar for all plannings. Three plans were evaluated and compared by using EUD and NTCP.
Results: For the bladder, rectum and both right and left femoral heads, the NTCP values were calculated less than %1 for the plannings with 6 MV, 15 MV and mixed energy plans. However, NTCP values to the bladder and rectum of mixed-energy plans were slightly lower than that of 6 MV and 15 MV plans.
Conclusions: The study does not show any significant differences between plannings with 6 MV, 15 MV and mixed energies with respect to NTCP. Also there is no significant difference in the dose distribution. However, the results of this study show that by using mixed-energy in aprostate IMRT plan, the bladder and rectum doses can be slightly reduced and the plan quality can be improved.

EP-1216
Prostate IMRT: dosimetric comparison between a clinical trial and clinical practice
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Purpose/Objective: Due to the complexity of the IMRT dose distributions, a modification in the clinical practice such as contour definition or prescription may have a dosimetric impact and has to be evaluated. This situation occurs for some clinical trials. This study aimed at comparing dose distributions obtained for two groups of patients representative of clinical practice and a particular clinical trial.
Materials and Methods: In our clinical practice, cancer prostate radiotherapy treatments consist in delivering 76Gy/38 fractions using IMRT. The following dosimetric objectives are considered for plan validation: PTV (D95%>95%), bladder wall (V65Gy<25%, V40Gy<50%), rectal wall (V70Gy<15%, V65Gy<25%, V38Gy<50%), and femoral heads (V50Gy<10%, V30Gy<50%). For a clinical trial, a new definition of contours and a new prescription were defined. Prescription was 78Gy/39 fractions with the following dosimetric objectives: CTV (D99%>78Gy), PTV (D95%>74.1Gy, D1cc<81.9Gy), bladder and rectal walls (D30%<72.8Gy, D50%<54.3Gy), femoral heads (D5%<54.3Gy). 30 patient treated between 2006 and 2012 were randomly selected from our database to create a control group. Mean number of MUs and homogeneity index ((D2%-D98%)/D50%) were calculated. For organs at risk, organs were delineated according to the clinical practice, and dose volume histogram values were reported. For the five first patients included in the clinical trial, contours and plans were validated following protocol recommendations. However, contours were also defined according to the clinical practice. For example, the bladder was contoured either only 18mm above the base of the prostate and in totality for clinical trial and clinical practice, respectively. For these 5 patients, usual dose volume histogram values were reported and compared to the control group.
Results: Homogeneity indices were 0.05±0.01 and 0.10±0.02 for CTV and PTV respectively for the control group. They were slightly better for the study group: 0.04±0.01 and 0.07±0.01. These results showed a satisfactory target volume coverage whatever the protocol. Compared to the control group, number of MUs was 8% higher for the study group. For the bladder, the dose histogram values were reported as a function of the percentage of the overlap between the bladder and the PTV. Results obtained for the control group showed a very good reproducibility and robustness of IMRT prostate planning procedures. Values reported for the study group were similar to the control group despite the higher dose prescribed to the target volume. Similar results were obtained for rectum and femoral heads.
Conclusions: This study showed that the clinical trial protocol led to dosimetric results similar to those obtained in our clinical practice despite the differences in contours and prescriptions. Physicians were therefore more confident to include patients in the clinical trial.

EP-1217
Comparison of volumetric modulated arc therapy and intensity modulated radiotherapy for pelvic malignancies
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Purpose/Objective: This study was performedto examine the potential role of volumetric modulated arc therapy (VMAT) in comparison with intensity modulated radiotherapy (IMRT) for pelvic malignancies.
Materials and Methods: Seven field dynamic IMRT and double arc VMAT plans were compared for ten pelvic cancer cases in terms of total monitoring units (MU), maximum dose, conformity index, uniformity or homogeneity index, integral dose and dose to normal structures. All the plans were created in eclipse version10 treatment planning system (TPS) and executed in Varian Clinax-iX linear accelerator through ARIA10 networking platform. Student's paired t-test was performed to compare the results.
Results: Average conformity index of IMRTplan was 1.5+/1 0.12, but the VMAT plans achieved on an average of 1.38±0.04(p-value of 0.016). Average uniformity index for VMAT plan was 1.05±0.01, but in IMRT it was 1.074±0.02 (p-value of 0.006). No significant difference was observed in maximum dose between IMRT and VMAT (p-value of 0.854). The integral dose (p-value of 0.003) and normal tissues dose was found less in VMAT plans compared to IMRT plans. The average MU needed to deliver the dose of 200 cGy per fraction was 415±33 for VMAT plans, while for IMRT plan it was 743±92(p-value of 0.000). VMAT plans involve two full rotation of gantry, so that it gives more freedom in dose modulation. In VMAT, image guidance improves tumour targeting and the fast delivery in less than 2-5 minutes helps to minimise the probability of intra fractional movement of target and critical organs. The reduction in treatment time gives more comfort and less stress to patients. Significant reduction of MU in VMATplans compared to IMRT may result in less leakage and scattered radiation and low overall peripheral dose.
Conclusions: The comparative study with VMAT versus IMRT employed in pelvic cancers proved, better normal tissues sparing and better target coverage by VMATcompared to IMRT technique.

EP-1218
Quality of radiation treatment planning in postmastectomy patients- comparison of 3D versus 2D plans